

AO

Report to the Chairman, Committee on  
Armed Services, House of  
Representatives

1994

TRIDENT II

D-A283 196



Reductions to MK-6  
Guidance System  
Inventory Objectives  
May Be Possible



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United States  
General Accounting Office  
Washington, D.C. 20548

National Security and  
International Affairs Division

B-257417

July 6, 1994

The Honorable Ronald V. Dellums  
Chairman, Committee on Armed Services  
House of Representatives

Dear Mr. Chairman:

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In response to your request, we have reviewed the Navy's rationale for procuring its planned number of MK-6 guidance systems for the Trident II submarine's D-5 missile. Our review focused on determining (1) the Navy's basis for computing its total program inventory objective for the guidance systems and (2) the effect that a reduction in this inventory objective would have on the overall reliability of the D-5 missile.

On April 29, 1994, we provided your office preliminary information on the results of our review. This report summarizes and supplements that information.

## Background

The Navy plans to have 10 Trident II submarines by the end of fiscal year 1997. Currently, it has six operational Trident II submarines and four others are under construction. Each Trident II submarine carries 24 D-5 missiles. Each D-5 missile is equipped with the MK-6 guidance system, which is comprised of an inertial measurement unit and an electronics assembly. The inertial measurement unit senses velocity and direction and relays this data to the electronics assembly, which issues flight control commands to the missile.

The Navy maintains spare MK-6 guidance systems onboard each submarine and in its logistics pipeline for test and maintenance purposes. The inventory objective is 570 inertial measurement units and 562 electronics assemblies. Through fiscal year 1994, the Navy had procured 525 inertial measurement units and 511 electronics assemblies. To meet its inventory objectives, the Navy plans to procure 45 additional inertial measurement units and 51 additional electronics assemblies before the guidance system acquisition program is completed. According to Navy officials, in fiscal year 1995 and beyond, \$318.2 million will be required to meet its guidance system inventory objectives. Appendix I provides additional information on the submarine-launched ballistic missile program and guidance system requirements.

## Results in Brief

The Navy's MK-6 guidance system inventory objectives are based on maintaining the D-5 missile system at the same high levels of readiness and reliability throughout the remaining 33 years of the Trident II program's life that were originally established between 1986 and 1987, during the Cold War era. To maintain these high readiness and reliability rates, the Navy calculated its program needs using methods that provided it with the highest number of MK-6 spares that might be needed at any time during the program.

The Navy carries six spare MK-6s onboard each patrolling submarine. Our analysis indicates that having three onboard spares would decrease the guidance system's operational readiness by only 3 percent (from 0.99979 to 0.96935) and having four onboard spares would result in only a 0.66-percent decrease (from 0.99979 to 0.99318). These decreases in MK-6 guidance system operational readiness would have a minimal effect on the overall D-5 missile system's operational readiness and reliability levels. A slight reduction in current operational readiness and reliability rates to levels that would allow for three onboard MK-6 spares would save approximately \$159 million. Reductions allowing for four onboard MK-6 spares would save approximately \$106 million. In addition, depending on the magnitude of inventory reductions, current readiness and reliability levels may be reduced for only a few years around the time that program needs are expected to be at their highest. In view of the break up of the Warsaw Pact and the Soviet Union, which ended the Cold War era, Trident missile and guidance system operational experience to date, the current budget environment, and the millions of dollars that could be saved if fewer MK-6s had to be procured, we believe the Department of Defense should consider whether slight reductions in readiness and reliability are acceptable.

## Navy's Calculation of Program Needs

The Navy calculated its Trident II MK-6 guidance system inventory objectives by projecting the number of electronics assemblies and inertial measurement units required to maintain the readiness and reliability goals, established during the 1986-1987 time frame, through the years when program needs are expected to peak<sup>1</sup> and through the remainder of the program's currently projected 38-year life (1990 through 2027). Navy officials told us that it is difficult to predict spares requirements for the program's life through the year 2027. Performance data are available for only 3 percent of the Trident II program's projected life, the Navy has no

<sup>1</sup>The Navy expects peak requirements to occur in the year 2018, when eight submarines are deployed and two others are being overhauled and refueled.

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experience maintaining a submarine-launched ballistic missile program for more than 20 years, unforeseen engineering challenges could arise, and the world threat could change. Despite these planning challenges requiring decisionmakers to make many assumptions about the future, all systems must be procured in the next few years to maintain continuous production.

The Navy's calculations included MK-6s (1) in missiles onboard deployed submarines; (2) already expended in missile test firings and planned to be expended in test firings through the life of the program;<sup>2</sup> (3) carried onboard submarines as spares and spares kept at the Strategic Weapons Facility; (4) used by contractors, designers, technicians, and shipyards for test purposes; (5) in the repair pipeline; and (6) discarded because they were no longer repairable. The Navy used past program experience, statistical analyses, and engineering judgment to develop its inventory objectives. The Navy's projected MK-6 guidance system needs are shown in table 1.

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<sup>2</sup>Missile test firings include the Commander in Chief Evaluation Test (CET) program of 28 initial missile flight tests, the Follow-on CET (FCET) program in which 6 missiles are flight tested each program year, and Demonstration and Shakedown Operation (DASO) tests that are conducted when submarines are commissioned or complete a major overhaul.

**Table 1: Projected MK-6 Guidance System Needs at Program Peak**

<b>Requirements in the year 2018 (8 deployed submarines)</b>	<b>Electronics assemblies</b>	<b>Inertial measurement units</b>
In missiles onboard submarines (24 per vessel)	192	192
Spare systems onboard submarines (6 per vessel)	48	48
Expended in missile test firings (CETs, FCETs, and DASOs)	201	201
Used for production acceptance testing (1 per contractor per production year)	17	17
Strategic Weapons Facility (needed to replace faulty systems on submarines returning from patrol)	12	12
Electronic assemblies used to test inertial measurement units at the contractor, the design agent, and other test sites (inertial measurement units are not required for testing electronics assemblies)	10	0
Used by shipyards to test submarine systems after construction or overhaul (no longer tactical assets)	10	10
Repair pipeline (undergoing repair, safety level, and in transit between the Strategic Weapons Facility and the repair facility)	43	61
Nonrepairable (estimated at about 1 per program year based on MK-5 experience)	29	29
<b>Total</b>	<b>562</b>	<b>570</b>

## Fewer Than Six Spares May Be Sufficient Onboard Submarines

The Navy calculated that each patrolling submarine must carry six spare MK-6 guidance systems to ensure that there is essentially a 100-percent probability that all missiles' guidance systems will be operationally ready if called upon for launch. Operational readiness is the prime element of overall system reliability<sup>3</sup> as the missile's performance is inconsequential if it is not first operationally ready. Our calculations show that current operational readiness goals can be met with four onboard spares and minimum weapon system reliability goals can be met with three. Our review indicates that fewer than six spares would be sufficient onboard Trident II submarines for the following reasons:

- Weapons system reliability requirements, established between 1986 and 1987 during the Cold War era, need to be re-evaluated in light of the current world environment.

<sup>3</sup>Overall weapon system reliability is dependent on the level of operational readiness, launch, and flight reliability achieved for a number of the weapon's subsystems, including, but not limited to, guidance, missile performance, fire control, navigation, and ship support.

- 
- Current onboard MK-6 spares' requirements provide overall system reliability levels that are higher than the Navy's minimum reliability goals set during the Trident II's milestone III review (approval to proceed into full-rate production).
  - In the past 2 years, there have been no Trident II patrols during which more than three MK-6 spares were needed. Of the 28 Trident II patrols during this period, 20 patrols had no MK-6 failures, 5 patrols had 1 MK-6 failure, 2 patrols had 2 MK-6 failures, and 1 patrol had 3 MK-6 failures.
  - The Trident I operational experience shows that the Navy usually carried at least twice as many spare guidance systems as were needed. Of the 647 Trident I patrols, 643 had 2 or fewer guidance system failures, 3 had 3, and only 1 had 4 failures. While we recognize that there are technical differences between Trident I and Trident II guidance systems and that Trident I performance may not be indicative of Trident II performance, the Navy uses the same methodology for computing spare guidance system requirements for both Trident I and Trident II systems.

Program office officials told us that their MK-6 guidance system inventory objectives are based on meeting overall weapon system operational readiness and reliability goals set by the Department of Defense. Any reductions in these goals would have to be made by the Department of Defense.

Appendix II provides additional information on the Navy's computation of onboard spares and our analysis of its requirements.

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## Recommendation

We recommend that the Secretary of Defense consider whether some slight reductions in the operational readiness and reliability goals established in the 1986-1987 time frame during the Cold War era are acceptable, in view of the threats that exist in the world today since the break up of the Soviet Union. If these reductions are acceptable, we also recommend that the Secretary reduce the number of additional MK-6 guidance systems to be procured. (See table II.2 for potential savings that could be realized under various options for reducing the Navy's current inventory objectives.)

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## Agency Comments

The Department of Defense concurred with our recommendation that a study should be performed to determine whether the current Trident II weapon system readiness goals remain appropriate, in light of the changes that have taken place in the world's political composition and threat. The

Department of Defense stated that as a result of this assessment, the number of spare MK-6 guidance systems ultimately procured might be reduced. The Department's comments are included in their entirety in appendix III.

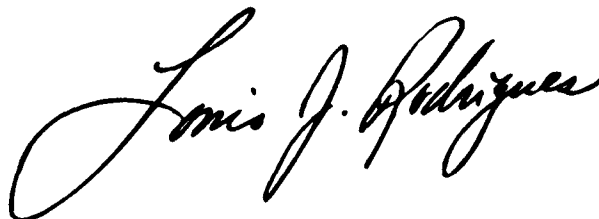
## Scope and Methodology

In performing our review, we interviewed officials and reviewed documents at the U.S. Strategic Command, Omaha, Nebraska; the Department of Defense's Office of Strategic Forces and Operations; the Navy's Submarine Warfare Division; Strategic Systems Program Office, Arlington, Virginia; Submarine Force, U.S. Atlantic Fleet, Norfolk, Virginia; and the Strategic Systems Office, Submarine Force, U.S. Pacific Fleet, Pearl Harbor, Hawaii. We performed our review from January through May 1994 in accordance with generally accepted government auditing standards.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 15 days after its issue date. At that time, we will send copies to the appropriate congressional committees and the Secretaries of Defense and the Navy. We will also make copies available to others on request.

Please contact me at (202) 512-4841 if you or your staff have any questions concerning this report. Major contributors to this report are listed in appendix IV.

Sincerely yours,



Louis J. Rodrigues  
Director, Systems Development  
and Production Issues



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## **Contents**

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## **Abbreviations**

<b>CET</b>	<b>Commander in Chief Evaluation Test</b>
<b>DASO</b>	<b>Demonstration and Shakedown Operation</b>
<b>FCET</b>	<b>Follow-on Commander in Chief Evaluation Test</b>

# Submarine-Launched Ballistic Missile Program and Its Changing Guidance System Requirements

## Submarine-Launched Ballistic Missile Program

Throughout the Cold War, the submarine-launched ballistic missile program provided a nuclear deterrence. Successive generations of submarines, missiles, and guidance systems, including the Polaris, Poseidon, Trident I, and Trident II systems, provided improved accuracy, range, survivability, and destructive power.

Despite the end of the Cold War, submarine-launched ballistic missile patrols continue. The Department of Defense contends that the primary threat that must be deterred continues to be the destructive capability of Russian strategic forces, and that the United States must maintain its nuclear forces to deter the full scope of threats to the United States and its allies.

The current submarine-launched ballistic missile program consists of eight Trident I submarines carrying C-4 missiles equipped with MK-5 guidance systems and six Trident II submarines carrying D-5 missiles equipped with MK-6 guidance systems. Four more Trident II submarines will enter the fleet by 1997. Currently, the Navy has no plans to develop systems to eventually replace the Trident IIs, which entered the fleet in 1989 and will be maintained until the year 2027 when the last Trident II is expected to be retired.

While on patrol, Trident submarines sustain the survivability of their ballistic missiles by remaining undetected. Opportunities for detection are minimized by virtually excluding outgoing communication and remaining submerged. Surfacing for medical emergencies or compelling humanitarian reasons, such as attending to a death in the family, are permitted.

## Program Changes Reduce Guidance System Inventory Objectives

In its fiscal year 1994 budget plans, the Navy reduced its D-5 missile and MK-6 guidance system inventory objectives, when a decision to backfit the Trident I fleet with Trident II missiles and guidance systems was postponed. In its fiscal year 1995 plans, inventory objectives were reduced further. These recent reductions are primarily the result of (1) the anticipated cancellation of the submarines' first scheduled overhaul and, therefore, a reduction in total program Demonstration and Shakedown Operations flight tests (plans had called for one overhaul after 12 years of operation and a second, to replace the nuclear core, after 20 years); (2) a decrease in the number of electronics assemblies reserved for use by repair, design, and test facilities inspecting inertial measurement units; and

**Appendix I**  
**Submarine-Launched Ballistic Missile**  
**Program and Its Changing Guidance System**  
**Requirements**

(3) a decrease in the number of inertial measurement units forecast to be in the repair pipeline.

Table I.1 reflects changes in the Navy's Trident II inventory objectives since fiscal year 1993.

**Table I.1: Changes in Trident II Inventory Objectives**

Fiscal year	Inventory objectives		
	D-5 missiles	MK-6 electronics assemblies	MK-6 inertial measurement units
1993	779	892	940
1994	428	596	620
1995	389	562	570

Table I.2 shows the Navy's plans for reaching its guidance system inventory objectives.

**Table I.2: Guidance System Procurement Plans**

	Electronics assemblies	Inertial measurement units
Delivered as of December 1993	383	386
Procured through fiscal year 1994, but not yet delivered	128	139
Procurement plans for fiscal year 1995	30	30
Procurement plans for fiscal year 1996 and beyond <sup>a</sup>	21	15
Inventory objectives	562	570

<sup>a</sup>The President's fiscal year 1995 budget did not include advanced procurement funding for a fiscal year 1996 guidance system buy, because the Navy is contemplating a new procurement strategy aimed at preserving the industrial base. It has not completed procurement plans for fiscal year 1996 and beyond.

# Our Analysis of the Navy's Rationale for Onboard Spare Requirements

According to Navy officials, underway replenishment of guidance systems is impractical; therefore, submarines on patrol must carry adequate spare guidance systems. Navy officials told us that returning to the Strategic Weapons Facility to receive additional spares or continuing to patrol with a reduced number of operational missiles could reduce target coverage. The submarine's crew does not have the technical expertise or equipment to repair the units onboard. When either a faulty electronics assembly or inertial measurement unit is identified it is removed and replaced. All guidance system repairs are done on shore by contractors.

The number of spare MK-6 guidance systems needed onboard a patrolling submarine was calculated based on the average number of inertial measurement unit failures per patrol, per quarter, over the past 2 years. Navy officials chose this method, claiming that it (1) weights all patrols equally regardless of length, (2) provides a conservative figure, and (3) has proven successful in estimating spares for prior programs such as the Trident I. The Navy's guidance system operational readiness goal is to have adequate spares available 99.9 percent of the time. The Navy also included a 99-percent confidence level factor in its calculations because, according to Navy officials, it provided a higher, more conservative result that helps ensure that sufficient spares will be available even in the event of unforeseen future system problems. Based on this methodology, the Navy calculated that six spare guidance systems are required on each submarine.

We requested that the Navy use the methodology described above to calculate the guidance system's operational readiness levels that could be achieved with incremental reductions to the number of spare MK-6 guidance systems onboard the submarines. The results of these computations are shown in table II.1.

**Table II.1: Guidance System Operational Readiness Levels Achieved With Six or Fewer Onboard Spares**

Number of MK-6 spares carried	Probability of having sufficient spare MK-6s (operational readiness levels)
6	0.99979
5	0.99872
4	0.99318
3	0.96935
2	0.88740
1	0.67602
0	0.31253

The Navy's guidance system operational readiness goal is also a factor in ensuring that the overall weapon system maintains a specific reliability rate. The Navy committed to maintaining an overall weapon system reliability level in 1987, during the Trident II program's milestone III review. Navy officials told us that to ensure that this overall weapon system reliability level is maintained, all subsystems, including guidance systems, are required to achieve very high levels of individual readiness and reliability resulting in a total system reliability rate 5 percent higher than the minimum rate agreed to at the milestone III review. This higher goal can only be achieved if the guidance system's operational readiness level is maintained at essentially 100 percent.

Navy officials acknowledged that the results of their guidance system failure rate analysis would be more accurate if more data were available, but given the newness of the program and because procurement must be completed in the next few years, this analysis at least provides an estimate for planning purposes. However, it should be noted that even though this data was taken from a small population size, the Navy used it to calculate the guidance system's operational readiness level with extreme precision. For example, as shown in table II.1, a difference in the guidance system's operational readiness level of 0.001 is considered significant enough to justify six onboard spares rather than five.

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## **Trident I Patrols Experienced Few Failures**

The Navy is using the same method for estimating Trident II onboard MK-6 spares that it used to estimate Trident I onboard MK-5 spares. According to Navy officials, this method has been successful as no Trident patrol has ever had more failures than it has had spares. However, this method often provided patrols at least twice as many spare guidance systems as were ever actually needed. Onboard spare requirements for Trident I submarines have ranged from six at the beginning of the program to a current requirement for four. Onboard requirements for Poseidon submarines carrying Trident I missiles have ranged from six to three depending on the reliability of the system and availability of spares. However, of the 647 combined Trident I patrols (Trident I and Poseidon submarines carrying Trident I missiles), 643 patrols had 2 or fewer failures, 3 patrols had 3 failures, and only 1 patrol had 4 failures.

## Savings Resulting From Lower Onboard Spare Requirements

Table II.2 provides cost savings resulting from inventory reductions based on changes to onboard spare requirements.

**Table II.2: Potential Savings From Reduced Onboard MK-6 Spares and Inventory Objectives**

Dollars in millions

Number of onboard spares	Reduction in guidance sets from current inventory for 2018 program peak <sup>a</sup>	Total number of systems still planned		Systems required in fiscal year 1995 under spare reduction options <sup>b</sup>		Systems required in fiscal year 1996 and out years under spare reduction options <sup>c</sup>		Potential savings <sup>d</sup>
		Electronics assemblies	Inertial measurement units	Electronics assemblies	Inertial measurement units	Electronics assemblies	Inertial measurement units	
6	0	51	45	30	30	21	15	\$ 0
5	8	43	37	30	30	13	7	53.0
4	16	35	29	30	29	5	0	106.1
3	24	27	21	27	21	0	0	159.1
2	32	19	13	19	13	0	0	212.2
1	40	11	5	11	5	0	0	265.2
0	48	3	0	3	0	0	0	318.2

<sup>a</sup>A guidance set includes one electronics assembly and one inertial measurement unit. Eight submarines will be deployed in the year 2018.

<sup>b</sup>Funding for 30 electronics assemblies and 30 inertial measurement units has been requested

<sup>c</sup>Procurement of 21 electronics assemblies and 15 inertial measurement units is planned.

<sup>d</sup>Based on fiscal year 1995 budget figures of \$6.63 million per guidance set (total cost, less advance procurement in prior years.)

# Comments From the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



## OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON  
WASHINGTON DC 20301-3000



June 22, 1994

Mr. Frank C. Conahan  
Assistant Comptroller General  
National Security and International  
Affairs Division  
U. S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Conahan:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report, "TRIDENT II: Spare MK-6 Guidance Systems for Missiles Can Be Reduced," dated June 3, 1994 (GAO Code 707025), OSD Case 9700. The DoD partially concurs with the report.

The DoD does not concur with the implication contained in the title of the GAO draft report. The DoD agrees there is a possibility that the MK-6 guidance system inventory could be reduced if performance requirements are relaxed. However, further analysis is required before that decision can be made.

The DoD does not concur with the GAO use of the phrase "Cold War" as the basis for current weapon system reliability requirements. It is the DoD position that the readiness and reliability requirements for U.S. strategic nuclear forces are not based on the existence of a political relationship known as the Cold War. Rather, they are based on the capabilities posed by the then-Soviet, and now Russian, strategic nuclear forces. The capabilities of those forces have not significantly changed, in spite of the changing political relationships.

The Trident fleet will be the backbone of the U.S. deterrent force well into the next century, in spite of the changing world environment. The submarines maintain their deterrent posture by operating in a survivable mode and by being able to threaten a devastating retaliatory attack in response to a massive strategic nuclear first strike. If a submarine did not have enough spare guidance sets on board to replace all that might fail, the United States could be faced with a shortage of retaliatory weapons. While the political relationship with Russia has recently improved, the United States should be able to strengthen its posture if the relationship deteriorates in the future, or if new strategic challenges arise. Because it would be neither cost effective nor timely to reestablish a production line for the guidance sets if the political relationship deteriorates sometime



See comment 1.

**Appendix III**  
**Comments From the Department of Defense**

during the lifetime of the Trident submarines and Trident II missiles (which could be as long as 40 years), it is necessary to ensure that enough guidance sets are produced now to meet that contingency.

The DoD does concur with the GAO recommendation that a study should be performed to determine whether the current TRIDENT II weapon system readiness goals remain appropriate in light of the changes that have taken place in the world political composition and threat capability. As a result of that assessment, the number of on-board spare MK-6 guidance systems ultimately procured might be reduced. However, it is unlikely that the results of that review will change the quantity of MK-6 guidance systems to be procured in FY 1995, as called for by the FY 1995 President's Budget submission. A one-third reduction in the number of on-board spares from six to four would reduce the total inventory objective by 20, which is essentially the quantity programmed to be procured in FY 1996 and beyond (as displayed in Appendix II of the GAO draft report). The DoD will complete this study after the Nuclear Posture Review submarine-launched ballistic missile force structure determination, in time to support the FY 1996 budget submission.

The detailed DoD comments on the draft report findings and recommendations are provided in the enclosure. Suggested technical changes were separately provided to the GAO staff. The DoD appreciates the opportunity to comment on the GAO draft report.

Sincerely,



George R. Schneider  
Director,  
Strategic and Space Systems

Enclosure

GAO DRAFT REPORT - DATED JUNE 3, 1994  
(GAO CODE 707025 - OSD CASE 9700)  
**"TRIDENT II: SPARE MK-6 GUIDANCE SYSTEMS  
FOR MISSILES CAN BE REDUCED"**

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**DEPARTMENT OF DEFENSE COMMENTS**

• **FINDING A: The Navy Calculation of Program Needs.** The GAO reported that the Navy MK-6 guidance system inventory objectives are based on maintaining the same high level of readiness and reliability throughout the remaining 33 years of the TRIDENT II program life—which was originally established during the Cold War. The GAO observed that, to maintain those high readiness and reliability rates, the Navy calculated its program needs using methods providing it with the highest number of MK-6 spares that might be needed at any time during the program.

The GAO explained that the Navy calculated its TRIDENT II MK-6 guidance system inventory objectives by projecting the number of electronics assemblies and inertial measurement units required to maintain Cold War readiness and reliability goals through the years when program needs are expected to peak. The GAO noted that the Navy calculations included MK-6s (1) in missiles onboard deployed submarines, (2) expended in missile test firings to date, (3) carried onboard submarines as spares and spares kept at the Strategic Weapons Facility, (4) used by contractors, designers, technicians, and shipyards for test purposes, (5) in the repair pipeline, and (6) discarded because they were no longer repairable.

The GAO further reported that the Navy expected peak requirements to occur in the year 2018, when eight submarines would be deployed, with two others being overhauled and refueled. The GAO reported that, according to Navy officials, it is difficult to predict spares requirements for the life of the program through the year 2027. The GAO pointed out that performance data are available for only 3 percent of the TRIDENT II program projected life and observed that the Navy has no experience maintaining a submarine-launched ballistic missile program for more than 20 years. The GAO pointed out unforeseen engineering challenges could arise and/or the world threat could change. The GAO further pointed out that, despite such planning challenges requiring decisionmakers to make many assumptions about the future, all systems must be procured during the next few years to maintain continuous production. (pp. 2-4/GAO Draft Report)

**DoD RESPONSE:** Partially concur. The DoD does not concur with the GAO use of the term "Cold War." Whatever the current relationship with nations of the former Soviet Union, the requirements for guidance sets were based on the capabilities of the then Soviet Union strategic nuclear forces between 1986 and 1987, and not the decades long political relationship known as the "Cold War."

Enclosure

Now on pp. 2-3.

See comment 1.

The DoD would also like to clarify that the total inventory objective of the TRIDENT II MK-6 guidance systems was calculated to meet the program support needs at the highest requirement period, i.e., the program peak. For clarification purposes, the GAO should indicate that the number of on-board spares is calculated to support the program through the minimum 38-year life (FY 1990 through FY 2027), reflecting the much tighter MK-6 guidance system tolerance compared to the TRIDENT I MK-5 guidance system, or indeed any of the five previous generations of Strategic Weapon Systems.

• **FINDING B: Fewer Than Six Spares May Be Sufficient Aboard Submarines.** The GAO found the Navy calculated each patrolling submarine must carry six spare MK-6 guidance systems to ensure that there is essentially a 100-percent probability that all the missile guidance systems will be operationally ready if called upon for launch. The GAO noted that overall weapon system reliability is dependent on the level of operational readiness, launch, and flight reliability achieved for a number of the MK-6 subsystems, including, but not limited to (1) guidance, (2) missile performance, (3) fire control, (4) navigation, and (5) ship support. The GAO concluded, however, that operational readiness goals could be met with four onboard spares—and minimum weapon system reliability goals could be met with three. In summary, the GAO concluded that fewer than six spares would be sufficient onboard TRIDENT II submarines, for the following reasons:

- The Cold War-based requirements needed to be reevaluated, in light of the current world environment;
- The current onboard MK-6 spares requirements provide overall system reliability levels that are higher than the minimum Navy reliability goals set during the TRIDENT II milestone III review (approval to proceed into full-rate production);
- In the past two years, there have been no Trident II patrols during which more than three MK-6 spares were needed (i.e., of the 28 TRIDENT II patrols during that period, 20 patrols had no MK-6 failures, five patrols had one MK-6 failure, two patrols had two MK-6 failures, and one patrol had three MK-6 failures); and
- The TRIDENT I operational experience showed that the Navy usually carried at least twice as many spare guidance systems as were needed, i.e., of the 647 TRIDENT I patrols, 643 had two or fewer guidance system failures, three had three, and only one had four failures, and while there are some technical differences between TRIDENT I and TRIDENT II guidance systems, the Navy uses the same methodology for computing spare guidance system requirements for both guidance systems.

The GAO reported that, according to program office officials, their MK-6 guidance system inventory objectives are based on meeting overall weapon system operational readiness and reliability goals set by the Department of Defense—and any reductions in those goals would have to be made by the Department. (pp. 6-7/GAO Draft Report)

Now on pp. 4-5.

See comment 1.

**DoD RESPONSE:** Partially concur. The DoD does not concur with the GAO use of the phrase "Cold War based requirements ...." Instead, the report should refer to "Weapons system reliability requirements ..." to more correctly state the basis for current weapon system reliability requirements. It is the DoD position that the readiness and reliability requirements for U.S. strategic nuclear forces are not based on the existence of a political relationship known as the Cold War, but are based on the capabilities posed by the then Soviet, and now Russian, strategic nuclear forces. The capabilities of those forces have not significantly changed, in spite of the changing political relationships. The requirements for U.S. deterrent forces were, and are, appropriately based.

The Trident fleet will be the backbone of the U.S. deterrent force well into the next century, in spite of the end of the Cold War and the changing world environment. The submarines maintain their deterrent posture by operating in a survivable mode and by being able to threaten a devastating retaliatory attack in response to a massive strategic nuclear first strike. A reduction in the number of MK-6 guidance sets on board each submarine could undermine the ability of the fleet to achieve that mission. If a submarine did not have enough spare guidance sets on board to replace all that might fail the United States could be faced with a shortfall in retaliatory weapons due to the inability to fire some of the Trident II missiles. Strategic planners must be able to reliably assess that all target assignments are covered and capable of being attacked. That cannot be ascertained if the submarine does not have sufficient spares to maintain all missiles ready to launch. The submarine could not terminate its patrol and proceed to port to take on board new guidance packages without drastically undermining the survivability of the fleet by revealing ballistic missile submarine locations, significantly reducing the target coverage, revealing a weakness in U.S. deterrent forces by alerting adversaries to the possibility that the U.S. missiles might not be able to fire in the event of a conflict, and complicating the ability of the U.S. to plan a retaliatory strike.

While the political relationship with Russia has improved, the United States should be able to strengthen its posture if the relationship deteriorates in the future. However, if the Navy purchases fewer guidance sets now and the relationship subsequently deteriorates, the United States would not have the assets it would need to strengthen the requirements for readiness and reliability. Because it would be neither cost-effective nor timely to reestablish a production line for the guidance sets if the political relationship deteriorates sometime during the lifetime of the Trident submarines and Trident II missiles (which could be as long as 40 years), it is necessary to produce enough guidance sets now to meet that contingency.

See comment 1.

The DoD also disagrees with the statement "While we recognize that there are some technical differences between Trident I and Trident II guidance systems." There are significant technical differences between Trident I and Trident II guidance systems, both in design and performance requirements. Failure histories of Trident I guidance systems, therefore, are not a reliable indicator of Trident II performance, although application of similar methodology to set logistics support requirements is appropriate. Specific differences include a service life length of twice as long, increased performance specifications, and 24 TRIDENT II missile tubes per submarine versus 16 missile tubes on C4 backfit TRIDENT Is.

Additionally, the statement that "TRIDENT I usually carried at least twice as many spares as needed" is misleading. Applying statistical analysis to logistic support would necessarily result in

few patrols with multiple failures and virtually none with four failures. Currently the TRIDENT I ballistic missile submarine carries four spares and has experienced a patrol in which all four spares were used. The operational readiness requirements are required to be met on every Fleet Ballistic Missile deterrent patrol. Therefore, whether or not the occurrence is once or multiple times is irrelevant from a logistics planning standpoint.

The TRIDENT I operational experience showed that, of the 647 TRIDENT I patrols, 643 had two or fewer guidance system failures, three had three, and one had four failures. The Navy uses the same methodology for computing spare guidance system requirements for both TRIDENT I and II guidance systems. However, because there are significant technical differences between TRIDENT I and TRIDENT II guidance systems, failure histories of TRIDENT I guidance systems are not a reliable indicator of Trident II performance.

The limited patrol performance data currently available suggest that the TRIDENT II strategic weapon system does exceed the minimum reliability goals. Specifically, for the first four years and only 3 percent of the average guidance system operational performance period, the MK-6 has already experienced three failures on one patrol. Given that actual experience in the early phase of deployment, coupled with the significant ambiguity associated with (1) technical differences between TRIDENT I and II guidance sets, (2) the existence of 33 percent more missile guidance sets to be maintained aboard the 24-tube TRIDENT II ships versus the 16-tube TRIDENT I C-4 backfit ships, (3) the much tighter performance specifications required of TRIDENT II guidance sets, and (4) the difficulties associated with predicting engineering performance some 30 years into the future, the DoD does not agree that spare guidance sets may be reduced below six per ship without degrading weapons system readiness below the levels required.

**FINDING C: Submarine-Launched Ballistic Missile Program.** The GAO observed that, throughout the Cold War, the submarine-launched ballistic missile program provided nuclear deterrence. The GAO reported that successive generations of submarines, missiles, and guidance systems, including the POLARIS, POSEIDON, TRIDENT I, and TRIDENT II systems, provided improved accuracy, range, survivability, and destructive power. The GAO further reported that, despite the end of the Cold War, submarine-launched ballistic missile patrols continued. The GAO noted that it is the DoD contention that the United States must maintain its nuclear forces as a deterrent to the ever-increasing number of countries suspected of developing or possessing nuclear weapons. The GAO found, however, that currently the Navy had no plans to develop systems for eventual replacement of the TRIDENT II, which entered the fleet in 1989, and will be maintained until the year 2027, when the last TRIDENT II is expected to be retired.

The GAO reported that the current submarine-launched ballistic missile program consists of eight TRIDENT I submarines carrying C-4 missiles equipped with MK-5 guidance systems, and six TRIDENT II submarines carrying D-5 missiles equipped with MK-6 guidance systems. The GAO reported that four more TRIDENT II submarines will enter the fleet by 1997. The GAO pointed out that, while on patrol, TRIDENT submarines sustain the survivability of their ballistic missiles by evading their adversaries, and that opportunities for detection are minimized by limited outgoing communication and restricted opportunities for surfacing. (The GAO noted that surfacing for medical emergencies or humanitarian reasons, such as attending to a death in the family, is permitted.) (p. 9/GAO Draft Report)

See comment 1.

Now on p. 10.

See comment 1.

**DoD RESPONSE:** Concur. Two clarifications, however, are required. First, the draft report inaccurately describes the need for the patrolling submarine to remain fully undetected and its modus operandi for doing so. While on patrol, TRIDENT submarines sustain the survivability of their ballistic missiles by remaining undetected by both U.S. and foreign assets. Opportunities for detection are minimized by virtually excluding outgoing communications and remaining submerged. (Surfacing for medical emergencies or compelling humanitarian reasons, such as attending to a death in the family, is permitted.)

See comment 1.

Second, the GAO description as to why the U.S. must maintain its nuclear deterrent is not accurate. The United States must maintain its nuclear weapons to deter the full scope of threats to the United States, its allies, and its forces overseas. The most important threat that must be deterred today remains the immense destructive capabilities of the Russian strategic forces. Although the change in government has led to an improved political relationship between the United States and Russia, the threat posed by the capabilities of current and projected Russian strategic nuclear forces has not diminished. Russia continues to maintain and modernize its strategic offensive forces, and those forces continue to be capable of threatening the survival of the United States.

• **FINDING D: Program Changes Reduce Guidance System Inventory objectives.** The GAO reported that, in the FY 1994 Navy budget plans, the Navy reduced its D-5 missile and the MK-6 guidance system inventory objectives, when a decision to backfit the TRIDENT I fleet with TRIDENT II missiles and guidance systems was postponed. The GAO reported that, in the FY 1995 Navy plans, inventory objectives were reduced further. The GAO observed that those recent reductions are primarily the result of (1) the anticipated cancellation of the first scheduled overhaul of the submarines and, therefore, a reduction in total program demonstration and shakedown operations flight tests, (2) a decrease in the number of electronics assemblies reserved for use by repair, design, and test facilities inspecting inertial measurement units, and (3) a decrease in the number of inertial measurement units forecast to be in the repair pipeline. (p. 10/GAO Draft Report)

Now on pp. 10-11.

**DoD RESPONSE:** Concur.

• **FINDING E: Analysis of The Navy Rationale For Onboard Spare Requirements.** The GAO reported that, according to Navy officials, submarines on patrol must carry adequate spare guidance systems, because (1) surfacing to receive spare systems would increase the vulnerability of the weapon system, and (2) because the submarine crew does not have the technical expertise or equipment to repair the units onboard. The GAO also reported that, when either a faulty electronics assembly or inertial measurement unit is identified, it is removed and replaced. The GAO learned that all guidance system repairs are done on shore by contractors.

The GAO found that the number of spare MK-6 guidance systems needed onboard a patrolling submarine was calculated based on the average number of inertial measurement unit failures per patrol, per quarter, over the past 2 years. The GAO also learned Navy officials chose that method because it (1) weighted all patrols equally, regardless of length, (2) provided a conservative figure,

and (3) had proven successful in estimating spares for prior programs such as the TRIDENT I. The GAO reported that the Navy guidance system operational readiness goal is to have adequate spares available 99.9 percent of the time. In addition, the GAO reported that the Navy also included a 99-percent confidence level factor in its calculations because, according to Navy officials, it provided a more conservative result and helped ensure that sufficient spares would be available—even in the event of unforeseen future system problems. The GAO concluded that, based on the described methodology, the Navy calculated six spare guidance systems are required on each submarine.

The GAO found that the Navy guidance system operational readiness goal is also a factor in ensuring that the overall weapon system maintains a specific reliability rate. The GAO reported that the Navy committed to maintaining an overall weapon system reliability level in 1987, during the TRIDENT II program milestone III review. The GAO reported that, according to Navy officials, to ensure the overall weapon system reliability level is maintained, all of the subsystems, including guidance systems, are required to achieve levels of individual readiness and reliability resulting in a total system reliability rate 5 percent higher than the minimum rate agreed to at the referenced Milestone III review. The GAO concluded that the higher goal can only be achieved if the operational readiness level of the guidance system is maintained at essentially 100 percent. The GAO also indicated the Navy acknowledged that the results of its guidance system failure rate analysis would be more credible if more data were available. The GAO observed, however, that given the newness of the program and because procurement must be completed in the next few years, the analysis at least provides (as one Navy official stated) a "ball park" figure for planning purposes. (pp. 12-14/GAO Draft Report)

**DoD RESPONSE:** Partially concur. The GAO understates the adverse effects upon a ballistic missile submarine mission were it not to have adequate spares to replace failed guidance sets, which are critical components essential for missile launch. Specifically, submarines on patrol must carry adequate spare guidance systems, because surfacing to enter port to receive spare systems, which is tantamount to terminating patrol and lapsing target coverage, would increase the vulnerability of the weapon system and reduce strategic effectiveness. The submarine crew does not have the technical expertise or equipment to repair the units onboard, and underway replenishment of guidance units is impractical.

The GAO description of the 99-percent confidence factor is vague where it refers to general conservatism. More correctly, it is an accepted statistical method to provide a degree of "insurance" to probability estimates where actual data are limited to a small fraction of the total population size. In the case at hand, predictions for more than 30 years into the future are being based on the first 3 percent of the system life performance data. Among other ambiguities, aging effects normally associated with precision equipment cannot yet be accounted for, making some degree of increased confidence appropriate.

The GAO description of the "5 percent higher" is a misinterpretation of Milestone III estimated performance and threshold requirements. The estimated performance was actually 5 percent better than the threshold, and the subsystem reliability specifications were based on that higher estimate.

Now on pp. 12-13.

See comment 2.

**FINDING F: TRIDENT I Patrols Experience Few Failures.** The GAO reported that the Navy was using the same method for estimating TRIDENT II onboard MK-6 spares that it used to estimate TRIDENT I onboard MK-5 spares. The GAO reported that, according to Navy officials, that method had been successful, since no patrol has ever had more failures than it had spares. The GAO contended, however, that the method often provided patrols at least twice as many spare guidance systems as were ever actually needed. The GAO reported that onboard spare requirements for TRIDENT I submarines had ranged from six at the beginning of the program to a current requirement for four. The GAO also reported that onboard requirements for POSEIDON submarines carrying TRIDENT I missiles had ranged from six to three, depending on reliability of the system and the availability of spares. The GAO concluded that, of the 647 combined TRIDENT I patrols (TRIDENT I and POSEIDON submarines carrying TRIDENT I missiles), 643 patrols had two or fewer failures, three patrols had three failures, and only one patrol had four failures. (p. 14/GAO Draft Report)

**DoD RESPONSE:** Partially concur. Although the data cited in the GAO Draft report on failures per TRIDENT I ballistic missile submarine patrol are accurate, the statement that "this method often provided patrols at least twice as many spares as needed" is both misleading and technically irrelevant. Currently, the TRIDENT I ballistic missile submarine carries four spares and has experienced a patrol in which all four spares were used. The weapons system operational readiness requirements are required to be met on every Fleet Ballistic Missile deterrent patrol. Therefore, whether or not a failure occurrence is once or multiple times is irrelevant from a logistics planning standpoint. From a statistical analysis perspective, a failure rate distribution similar to that actually experienced (i.e., few patrols with multiple failures) would be expected, given the high reliability requirements imposed.

The methodology used to predict the inventory objective for the TRIDENT II MK-6 guidance system is based on the experience gained in previous Fleet Ballistic Missile programs. Specifically addressing the TRIDENT I experience, during the peak requirements period, an anomaly was discovered in the monitor drive module that supports the stellar sensor. That resulted in the systems being recalled from the fleet, reducing the available onboard spares. Daily asset management was required to ensure overall program requirements were met until the necessary upgrades were made to the spares inventory. That is an example of an unplanned development that the inventory projections must accommodate as systems age.

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#### RECOMMENDATIONS

**RECOMMENDATION 1:** The GAO recommended that the Secretary of Defense consider whether some slight reductions in Cold War-based operational readiness and reliability goals are acceptable. (p. 7/GAO Draft Report)

**DoD RESPONSE:** Partially concur. The DoD will initiate a study to determine whether reductions in existing operational readiness and reliability goals are acceptable. That study will be

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completed in time to support the FY 1996 budget submission. The on-going DoD Nuclear Posture Review is reviewing the current strategic nuclear force structure. The Nuclear Posture Review is examining operational readiness and reliability goals as a part of determining the overall force structure. The Nuclear Posture Review is considering all force structure options to ensure that the DoD-proposed strategic force structure will provide the optimum balance of strategic readiness and deterrence versus cost. The determination by the Nuclear Posture Review on submarine-launched ballistic missile force structure is expected in time to support the FY 1995 budget cycle.

Using the force structure determined by the Nuclear Posture Review as a prime input, the DoD will then decide whether the current TRIDENT II weapon system readiness goals remain appropriate in light of the changes that have taken place in the world political composition and threat capability since the disestablishment of the Warsaw Pact and the demise of the Soviet Union.

**RECOMMENDATION 2:** The GAO recommended that, if the reductions identified in connection with Recommendation 1 are acceptable, the Secretary should reduce the number of additional MK-6 guidance systems to be procured. (p. 7/GAO Draft Report)

**DoD RESPONSE:** Concur. As a result of the review of TRIDENT readiness and reliability discussed in the DoD response to Recommendation 1, the number of on-board spare MK-6 guidance systems ultimately procured may be reduced. However, it is unlikely that the results of the review will affect the quantity of MK-6 guidance systems procured in FY 1995, as reflected in the FY 1995 President's Budget submission. Even a one-third reduction in the number of on-board spares from six to four would reduce the total inventory objective by 20, which is the essentially the quantity remaining to be procured in FY 1996 and beyond (as displayed in Appendix II of the GAO draft report).

It should be noted that the MK-6 guidance system has already experienced three failures on one patrol in a system that has been deployed only 4 years, and just 3 percent of the average operational hours to be experienced by the guidance systems on the ten TRIDENT II ballistic missile submarines over their 30-year life through FY 2027. A reduction below four on-board spares is extremely unlikely given that history. The GAO discussion of the possibility of a reduction to three spares reflects only the very small sample size and limited performance data available to date, with no allowance for future aging or other effects on guidance system performance.

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**GAO Comments**

The following are GAO's comments on the Department of Defense's letter dated June 22, 1994.

1. We have revised our report to include this information.
2. We have addressed this comment in the report text.

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